Creating Riparian Habitat Along a Drainage Ditch in the Kawartha Lakes

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Abstract

The creation of a riparian zone along the drainage ditch and surrounding area was funded by a grant from the Ontario Trillium Foundation received by the Kawartha Land Trust. The site had been previously assessed by the author and the information was used to complete this project. The ditch was naturally divided into 3 sections. Sixty-one, 4m by 4m plots were planted with one tree and 3-5 shrubs each. Trees and shrubs were selected with emphasis on site conditions, ecology of the area, and their ability to provide food and create habitat. Over time, the shrubs should spread out and the tree canopies should close over between the plots. One side of each ditch section was planted with wildflowers. However, the success of this is uncertain due to insufficient site preparation. The wildflowers allow continued access to the ditch and increase the diversity of the otherwise grass-dominated habitat. Volunteers did all the planting over two days. Each tree received rodent and deer protection along with a mycorrhizal inoculant. Future recommendations included planting more shrubs and trees closer to the stream, stream assessment and improvement, adding herbaceous species to the existing plots and adding more plots to create forested areas. As the trees and shrubs mature the area will meet the objectives of improving habitat, providing food and contribute to preventing runoff from entering the stream and flowing into the nearby wetland. Having a variety of habitats on agricultural land including, woodlands, wetlands and riparian areas, provides many services to both the farmer and the surrounding ecosystem.

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Introduction

The Kawartha Land Trust (KLT) received a grant through the Ontario Trillium Foundation. The grant was to fund projects involving private landowners of significant natural areas. This included restoration and conservation projects initiated by reaching out to landowners of large 100+ acre properties. The KLT identified 250,000 acres of privately owned land in the Durham, Haliburton, Kawartha and Pine Ridge areas that are considered important but have no conservation or protection status (Hendren, 2016).

The location of this project is on a large property of approximately 1215 hectares in the Kawartha Lakes region of Ontario (44°26'7.71"N, 78°33'50.41"W). The property includes a lake and several wooded areas. It drains into a provincially significant wetland to the west. Currently it is used as farmland but the landowner has done habitat enhancement work in the past and has an interest in doing more (T. Unrau, personal communication, October 23, 2017). The project is located around a man made drainage ditch that drains the fields and a wetland area (Figures 1 and 2). The ditch is surrounded by grasses and contains no man made structures. The lack of trees and large vegetation leave it exposed to drying and erosion. Creating a riparian zone and forested area around the stream would be a step towards connectivity with the nearby wetland, especially since populating this upstream area will, given time, likely facilitate passive colonization of the riparian areas downstream (Bourgeois, González, Vanasse, Aubin & Poulin, 2016a).

Figure 1: The ditch and surrounding area. Located 44°26'7.71"N, 78°33'50.41"W

Figure 2: Ditch Area

The main issue on the site is a simplistic habitat not characteristic of the historical or likely future habitat in this area. The initial site assessment determined that before being converted to farmland this was a mixed woodland area (Marland, 2017). Benayas, Bullock, and Newton (2008) suggest that trees and shrubs in agricultural land provide important services to both the farmer, by providing habitat for pollinators and the natural enemies of many pests, and the ecosystem through carbon sequestration, improved soil fertility, protection from erosion, and water retention. Their study also found that trees and shrubs planted in clusters were more effective at providing these services than individual trees. An additional benefit is that these woodlands help speed up succession by providing a source of seeds. This site already contains several wooded areas among the fields, but they are drier sites with no surface water so the species present vary somewhat from riparian areas.

Although preventing chemical runoff into the nearby wetland is a concern, Yang et al. (2014) found that having objectives of both filtration and habitat creation often results in only satisfactory results in both. This influenced a decision to focus mainly on habitat creation. By creating a healthy habitat, filtration will happen as a natural consequence of a functioning ecosystem.

The results of the assessment were recommendations for many species that could be planted in the area to increase diversity and restore the habitat (Marland, 2017). This project involves the planning and planting of some of those species along with recommendations for future plantings. The objectives of this project are to design and plant the beginnings of a restored stream and riparian zone based on the results of the site

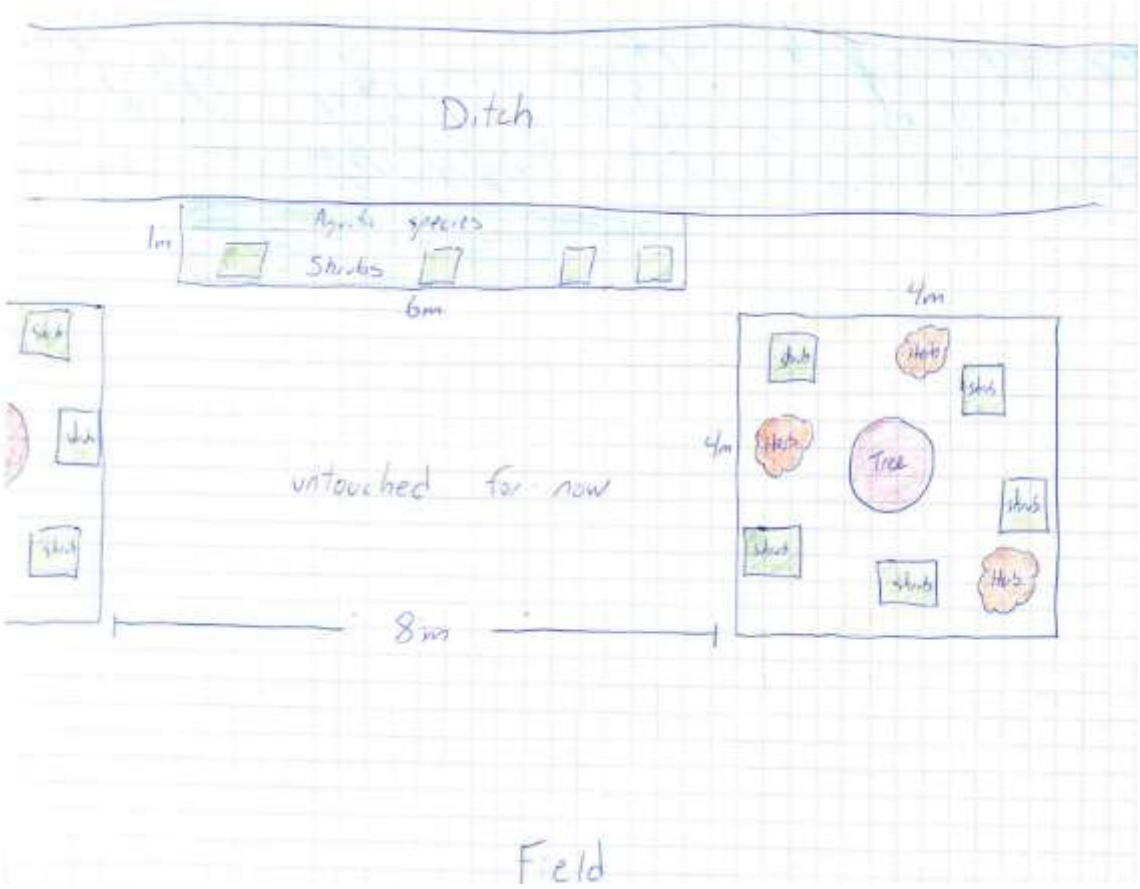
assessment with a focus on creating habitat, providing food and, in the long term, preventing agro chemical runoff into the wetland.

Methods

The ditch is divided in 3 sections, referred to as Ditch Section 1 (DS1), Ditch Section 2 (DS2) and Ditch Section 3 (DS3) moving east to west. The basic concept is six plants, one tree and five shrubs, in a 4m by 4m area. This planting density was found to be effective at suppressing invasive grasses by Kim, Ewing, and Giblin (2006) and Quinn and Holt (2009). The concept of planting groupings of shrubs or trees was also used successfully by Kellner (2014) and had a greater survival rate than randomly planted individuals. Due to the large area it was decided that the groupings would be spaced out to be more cost effective but at a spacing that could result in a closed canopy as the trees matured. This was estimated to be 8m between each 4m plot based on a general observation of tree canopies and consideration of project cost.

The initial plan involved herbaceous plants, both terrestrial and aquatic, along with trees and shrubs (Figure 3).

Figure 3: Initial concept for the site.



Species selection was done by researching historical forests of the area along with species present in the area. To meet the objective of providing habitat, preference was given to species that would provide food and shelter throughout the year. Appendix 1 contains the initial tree list, preferred conditions and benefit to the ecosystem. Consideration was also given to soil and site conditions. This was tricky given the high volume of clay in the soils. In a wet season it will drain poorly and in a dry summer it will be hard due to a combination of compaction and the nature of clay soils to shrink as they dry (Brady and Weil, 2008).

Other members of the KLT reviewed the species list and adjustments were made based on their suggestions. Trees were then grouped with shrubs that shared similar soil and moisture preferences. Canopy density and height was also considered with a goal of creating conditions suitable for woodland herbs but too shaded to be welcoming to invasive grasses and Common Buckthorn (*Rhamnus cathartica*) (Bourgeois et al., 2016b). Changing light conditions as trees and shrubs mature was considered and a mix of shade tolerant species, such as Ironwood and Basswood, along with full sun requiring species, like White Birch and Tamarack, were selected. Table 1 shows the second draft of tree species and their initial shrub groupings.

Table 1: A) Shrub Groupings and B) Trees with assigned shrub group

A)

Group	Species	Requirements
A	Choke Cherry x1, Alternate Leaved Dogwood x2, Black Huckleberry x2	good drainage, tolerates shade, good for sloped areas
B	Pussy Willow x1, Nannyberry x2, Red Osier Dogwood x2	ok for wetter sites tolerate some acidity
C	Speckled Alder x1, Winterberry x2, Gooseberryx2	wetter sites, Gooseberry and Winterberry can tolerate acidic sites
D	Smooth Serviceberry x1, Witchhazel x2, Wild Raspberry x2	Witchhazel likes partial shade to full shade, good for drier sites and range of dry to moist soil conditions
E	Elderberry x1, Prickly Rose x2, High Bush Cranberry x2	wetter site for Elderberry but others ok with normal to moist

B)

Tree	Grouping
Eastern White Pine	B
White oak	D
White Spruce	C
White birch	D
American Mountain Ash	E
Black Cherry	A
Shagbark Hickory	E
Eastern Hemlock	C
Red Maple	A
Silver Maple	D
Yellow Birch	C
Bitternut Hickory	B
Ironwood	A
Tamarack	C
Balsam Poplar	E
Trembling Aspen	B
Basswood	C
Bur Oak	A

Specie locations were determined by walking through the site at different times of the season and observing microsite characteristics. Species tolerant of variable conditions where placed in drier, rockier areas (DS3) and those with more specific preferences, such as moisture or rich soils, were placed as close to those conditions as possible (DS1 and DS2).

Various books, websites and people were consulted regarding deer protection options. According to the sources, the best method appeared to be a chicken wire fence of 1.5m with 2 lines of wire spaced 30cm apart at the top, creating a 2m fence around each 4m by 4m plot (Kopp, 2007; Soderstrom, 2008). Rodent guards were also acquired. Stakes for trees were planned based on the staking method recommended by Peterborough Green Up (N.D.). Given the windy nature of the site it is important that the trees become wind firm but also that they survive long enough to establish themselves.

Invasive Buckthorns were removed by backhoe and the site was planted with clover. The property manager did this during the site assessment before any plan was in place.

The issue of access to the ditch by machinery was addressed by planting wildflower seeds along one side of each section of the ditch. The species selected (see Table 3) were based on research and an appropriate mix was found from a seed distributor.

Several nurseries were contacted to determine who had the best selection, condition and price for trees and shrubs. Trees were ordered from Baker Forestry. Bare root shrubs came from Pine Needle Farms and the wildflower seeds were ordered from Wildflower Farms.

Site preparation for the wildflowers involved disking the planting area. This is not the ideal site preparation as recommended by Goldberger and Jenkins (2017), but the funding and time needed for appropriate preparation did not exist. The sites for the tree and shrub groupings where marked out with flags. In areas with thick grasses, a weed whacker was used to clear patches for the shrubs. The tree holes were dug with a small backhoe because of the large rocks and compacted soils. An attempt was made to stager the tree locations so they reflected a more random distribution.

Topsoil was available from the area but it was not used. Coco mats were considered to be the best mulching and weed control option since they required the least amount of monitoring and the site will not be intensively managed. Trees received mats 60cm in diameter while the shrubs were given 27cm mats. This was based on cost and the assumption that larger mats around the trees would regulate moisture and reduce competition while most of the shrubs would be more tolerant of competition and grow faster. A mycorrhizal inoculant, Myke Pro Landscape, was purchased to assist the shift in soil organisms from those associated with grassland root systems to those associated with woody shrub and tree roots (Arora, 1986; Creamer, Filley, Boutton & Rowe, 2016)

Friday and Saturday were scheduled for planting with volunteers, preceded by a day of site prep and followed by several days of finishing tasks. Plants were staged in their groups at each site and volunteers, five people on Friday and six people on Saturday, planted the trees in the center with the shrubs randomly placed at the discretion of the planter. Volunteers were given instruction on how to plant trees including depth and handling. They were also instructed that the mycelium should be placed in contact with the roots at the bottom of the hole and around the sides (MykePro, 2017).

The wildflower seeds were mixed with saw dust as recommended by Goldberger and Jenkins (2017) and broadcast by hand by volunteers

Three days following the volunteer days were spent putting in stakes and adding deer and rodent protection.

Results

Due to the time of year, budget constraints and time, the original plan was limited to trees and shrubs. Some trees where not available so species and numbers were altered accordingly. The most cost effective method of purchasing shrubs was bare root with a minimum order of 25 per species. No evergreen shrubs were available. Table 2 shows the actual trees and shrubs and the cost. It was noticed after placing the orders that one bundle of shrubs was not included in the final order. This resulted in a shortage of shrubs so some trees were only planted with 3 or 4 shrubs. These alterations changed the

groupings, which attempted to follow the pattern of Table 1 but ultimately became a random mix of what was available combined with brief consideration of tree type and location. Final tree locations are mapped in Figure 4 but shrub locations were not documented.

Table 2: Final Tree and Shrub Species

Species	Common Name	Size	Quantity	Price Per unit	Total
Pinus Strobus	White Pine	90-120cm	3	45.00	135.00
Quercus alba	White Oak	125-150cm	4	35.00	140.00
Picea glauca	White Spruce	60-90cm	4	8.50	34.00
Betula papyrifera	White Birch	200-225cm	5	25.00	125.00
Prunus serotina	Black Cherry	200-225cm	4	55.00	220.00
Carya ovata	Shagbark Hickory	60-90cm	3	13.75	41.25
Tsuga canadensis	Eastern Hemlock	30-60cm	1	7.25	7.25
Acer rubrum	Red Maple	125-150cm	6	18.00	108.00
Acer saccharinium	Silver Maple	225-250cm	4	50.00	200.00
Betula alleghaniensis	Yellow Birch	175-200cm	1	50.00	50.00
Carya cordiformis	Bitternut Hickory	30-60cm	1	11.75	11.75
Ostrya virginiana	Ironwood	30-60cm	4	7.50	30.00
Larix laricina	Tamarack	175-200cm	3	19.85	59.55
Prunus pensylvanica	Pin Cherry	175-200cm	3	13.50	40.50
Prunus pensylvanica	Pin Cherry	150-175cm	1	15.00	15.00
Populus tremuloides	Trembling Aspen	150-175cm	4	10.50	42.00
Tilia americana	Basswood	125-150cm	4	20.50	82.00
Quercus macrocarpa	Bur Oak	150-175cm	3	40.00	120.00
Acer saccharum	Sugar Maple	175-200cm	3	52.00	156.00
Shrubs					
Sambucus canadensis	American Elderberry	45-60cm	25	2.70	67.50

Hamamelis virginiana	Witchhazel	45-60cm	25	3.00	75.00
Viburnum trilobum	American High bush Cranberry	45-60cm	25	2.00	50.00
Cornus sericea	Redosier Dogwood	45-60cm	25	1.50	37.50
Cornus racemosa	Grey Dogwood	45-60cm	25	2.50	62.50
Amelanchier alnifolia	Serviceberry	45-60cm	50	2.30	115.00
Prunus virginiana	Choke Cherry	45-60cm	25	2.50	62.50
Salix discolor	Pussy Willow	1 gal	11	5.00	55.00
Rubus idaeus	Wild Red Raspberry	30cm+	25	2.50	62.50
Alnus Rugosa	Speckled Alder	30-45cm	25	3.00	75.00
Viburnum lentago	Nannyberry	45-60cm	50	2.50	125.00

Figure 4: Tree locations in each ditch section.
A) Ditch Section 1

B) Ditch Section 2

C) Ditch Section 3

The wildflower and grass species are listed in Table 3 along with the percentage of each in the mix. It is expected there will be reduced success in these sections due to the lack of site preparation.

Table 3: Wildflower mix: Claybusters Mix supplied by Wildflower Farms.

Latin Name	**Common Name**	**% by seed count**
Agastache foeniculum	Anise Hyssop	3.49
Aquilegia canadensis	Wild Columbine	0.74
Baptisia alba	White False Indigo	0.13
Coreopsis lanceolata	Lance Leaf Coreopsis	3.10
Dalea purpurea	Purple Prairie Clover	3.49
Desmodium canadense	Canada Tick Trefoil	0.43
Echinacea pallida	Pale Purple Coneflower	4.03
Helianthus maximilliani	Maximillian's Sunflower	1.01
Heliopsis helianthoides	Ox Eye Sunflower	1.47
Liatris pycnostachya	Prairie Blazingstar	3.42
Monarda fistulosa	Bergamot	2.72
Oligoneuron rigidum	Stiff Goldenrod	3.18
Parthenium integrifolium	Wild Quinine	1.09
Penstemon digitalis	Smooth Penstemon	5.04
Ratibida pinnata	Yellow Coneflower	2.33
Rudbeckia hirta	Black Eyed Susan	7.14
Symphyotrichum novae-angliae	New England Aster	2.56
Tradescantia ohiensis	Spiderwot	1.03
Vernonia fasciculata	Ironweed	1.86
Veronicastrum virginicum	Culver's Root	6.21
Zizia aurea	Golden Alexander	0.85
Total Wildflower Seeds		55.31
Native Grasses		
Elymus canadensis	Canada Wild Rye	12.09
Schizachyrium scoparium	Little Blue Stem	23.29
Sorghastrum nutans	Indiangrass	9.31
Total Native Grasses		44.69
Nurse Crop		
Lolium multiflorum	Annual Rye Grass	N/A

The south side of DS2 was left untouched because it had various flowers and grasses blooming at multiple times of the year. An exact inventory was not done but it was observed to be a mix of weeds and grasses. Removing those to plant wildflowers with an unknown probability of success would likely give a greater advantage to a homogenous Quackgrass (*Elymus repens*) and Reed Canary Grass (*Phalaris arundinacea*) habitat. The species present appeared to be succeeding at suppressing those invasive grasses so altering that side of the ditch seemed to violate the do no harm principle.

All of the trees received a plastic rodent guard but only approximately half of the shrubs in DS2 received them. This was because the guards were left over from a previous project and the decision had been made not to purchase more.

The original proposal for deer protection was determined to be too expensive so as an alternative each tree was surrounded with 4 stakes cut from 2x2 lumber. For larger trees the idea of wire was adapted to deter deer from bending the trees and doing permanent damage (Figure 5).

Figure 5: Wire used to keep deer from bending taller trees.

The spacing between wires was about 30cm and the wire was stapled to the stakes to help keep it in place.

Trees that were at head height for a deer were surrounded with chicken wire or orange snow fence plastic that was supplied by the property manager (Figure 6).

Figure 6: Deer protection for medium sized trees.

Very small trees were surrounded by fence right to the ground (Figure 7). In some cases the top was also covered with chicken wire.

Figure 7: Deer protection for very small trees.

The stakes doubled as support stakes for the trees that needed it. Table 4 compares the costs of the two systems of deer protection.

Table 4: Cost comparison for fencing the entire 4m by 4m area verses the adapted solution of only protecting large trees.

Proposed fencing of rebar and fencing around 4m by 4m area	$4676.96
Final solution of 2x2 wood posts and various deterrents*	$526.3

* Orange snow fencing was supplied by the property manager and was not included in the cost

The final result was 61 trees all with rodent guards and some form of deer browse deterrent. Trees that needed added support where staked but in a manner that allowed them to move in order to establish wind firmness. Each tree was surrounded by 3-5 shrubs. Mycelium was added to the shrub and tree roots. The total cost of the project, not including labour, which was volunteered, was $6406.58 (Table 5).

Table 5: Cost Breakdown

Item	**Cost**
Trees	$2223.61
Shrubs	$974.63
Wildflowers	$2235.68
Materials	$972.66
Total	**$6406.58**

Discussion

This area has great potential for various techniques of restoring a fresh water stream, riparian zone and forest. What has been planted with hopefully, eventually, close the canopy over the spaces between 4m plots and the shrubs will spread out. Creating a forested area with a variety of plants supplying food and shelter. The shaded environment should also reduce competition from invasive grasses.

It has been suggested by numerous studies that one of the ways to fight invasive species and create resilient plant communities is to occupy all the resources and niches within the community (Bakker & Wilson, 2004; Davis, Grime & Thompson, 2000; Fargione & Tilman, 2005; Funk et al., 2008; Naeem et al., 2000; Sheley & Krueger-Mangold, 2003). That is to say all depths of soil, taking up nutrients and water resources, and monopolize the sunlight. Although many of these studies focused on grasslands, it seems reasonable to assume a similar approach should work on this site. The tree and shrub species selected attempt to achieve this. Some species have deeper roots others spread out. Some are shade tolerant while others are sun tolerant, which, along with varying growth rates, will create a varied canopy. Eventually some trees will be shaded out but will add to the habitat as snags and coarse woody debris (CWD). The openings they leave in the canopy will also restore the natural gap-driven disturbance of forests in this area. Competition for light between the newly planted trees will take a number of decades so it may be helpful to add CWD in the near future. One tree from the earlier assessment fell down before the project began and was left in place to start this process.

Trees were selected that live for different lengths of time. There are some short-lived species such as Trembling Aspen. Other trees are long lived, like White Oak, and will continue to provide shelter and food (Government of Ontario, 2018). There is also a mix of seral stage species present including Trembling Aspen, which is common in early seral stages. Maples are a likely climax species based on other stands in the area. Although, the addition of oaks and conifers will make it interesting to see if a different species begins to dominate the canopy. The shrubs will help provide soil and moisture stabilization, wind protection and assist the succession from grassland to forest (Benayas et al., 2008).

The overall diversity of species selected will, in addition to meeting the objectives of habitat and food, contribute to resistance by containing species that will survive changing conditions and eventually find their own balance. D'Antonio and Thomsen (2004) suggested that a successful restoration strategy should focus on resistance and use the processes of succession in whatever means are most appropriate for a given system. Kennedy et al. (2002) recommends establishing communities with as much diversity of plants as ecologically realistic and logistically feasible. Among the benefits already discussed, they add that diverse communities will probably require less monitoring and maintenance.

Soil characteristics are important in determining what species do well and their resistance to disturbance and invasion (Callaway et al., 2004). The addition of mycelium targeted towards the roots of woody species should assist in establishing the riparian and woodland area. Attention to the microbe community is essential in in restoring the function of an ecosystem. The microbial community interacts intimately with larger flora and fauna and if the goal is to restore a functioning ecosystem it must include the soil to maximize the potential of success (Montoya, Rogers & Memmott, 2004).

This site would still benefit from more intervention, which will be discussed in the recommendations section.

Sources of Error

A scheduling issue with the delivery of the shrubs made it difficult to monitor the actual planting process. A walk through after planting revealed potential issues. Some trees were planted in depressions. This may prove to be a problem as trees may remain in wet conditions longer than desired. One way this issue could have been resolved would have been to dig the holes by hand once the tree was on site. The pre-dug holes were often larger and deeper than needed. The holes had to be filled in to plant properly, as they were generally too wide and too deep. However, this may be an advantage in the long run as it reduced compaction around the roots and created irregularly shape holes, which are less likely to cause the trees to become root bound (Peterborough Green Up, 2017).

The late delivery of plants also created challenges in keeping the bare root species moist. It was a hot sunny day and they dried out faster than they could be kept wet. It is unknown what effect this will have on shrub establishment.

Another issue was coco discs that were not sitting directly on the soil. Only the very dense spots were cleared by a weed whacker. The result was that some coco discs were place around the plant but on top of existing vegetation. This allowed light underneath to permit plants to grow and displace the mats, defeating the ability of the discs to control competition. A sweep was done to correct this but no tools were available and time was limited so the vegetation was pulled by hand and only enough so the mats would sit directly on the ground.

It was observed that some of the mycelium was sprinkled on top of the soil. This could have been extra but it is difficult to know if all plants received the recommended amount of mycelium in contact with roots.

Some of the stakes were placed too close to the trees making the wire less effective at keeping deer from sticking their heads in to browse. The deer deterrent of simply wire is a very experimental option. It was also much more time consuming. The snow fence stapled to the stakes was much faster and likely more effective. It is unknown how well either system will stand up to the winter.

Browsing was already observed on some plants a few days after planting. Suggesting that the original deer fencing may have been the better option. The shrubs may fall victim to deer.

The technique of clearing patches for shrubs was questionable. Mowing the whole area was the alternative suggestion. This option had been considered but the option of clearing patches won based on cost and the suggestion by PFLA (N.D.) that plants can be protected from deer by "hiding" them amongst other plants. Again an experimental theory and only DS1 has the type of ground cover that might accomplish this.

Monitoring and Maintenance

The funding needing to be spent by a deadline meant that money could not be set aside for future maintenance. However, maintenance could potentially be incorporated in the KLT budget and planning in future seasons. The main things needing to be addressed in the spring will be the state of deer protection, tree and shrub survival, possible replacement of dead species, weed control and invasive species removal. Particularly noting and removing any Buckthorn that returns. This process will need to be repeated for at least 5 years for most species and longer for some of the smaller trees (TRCA, 2015). In the fall, most of the trees with support stakes will need to be released to further improve their wind firmness (Peterborough Green Up, 2017 & Kopp, 2016).

Measuring tree diameters and heights may be helpful in determining which ones are doing particularly well with the site conditions and can help inform future planting decisions.

Future Recommendations

In addition to the recommended maintenance there are several steps that would facilitate a faster progression towards a forested stream habitat.

The banks along the ditch have a good covering of grasses and other plants; erosion appears to be only a minor problem. However, planting shrubs, such as Willow, Dogwood and High Bush Cranberry along the banks would help ensure erosion does not become a problem in the future. It would also increase the amount of shade over the stream, which would help maintain the temperature and habitat quality. When the site was first visited, the stream was completely filled with cattails. Shading over the water might make the stream less hospitable to the cattails and result in more open water that can be populated by other species. Figure 8 shows areas were additional shrubs could be planted based on erosion prevention, creating more shade and improving riparian habitat.

Figure 8: Areas for additional shrubs and some trees.

Other areas that could be improved are the low-lying drainage areas in DS1. Nothing was planted here due to a need for more information regarding drainage patterns and maintenance. If the farmer considered it acceptable, species such as willow, that can be cut back and easily recover, may do well in these areas. Figure 9 shows these areas.

Figure 9: The low-lying drainage areas are circled in blue.

Plants for both the banks and the drainage areas could be supplied with cuttings from the area. Table 6 lists the species that are present and could be used for this purpose. The list does not include the shrubs that were recently planted. If those shrubs establish they could also be used as cuttings.

Table 6: Species on site that can be propagated for future plantings.

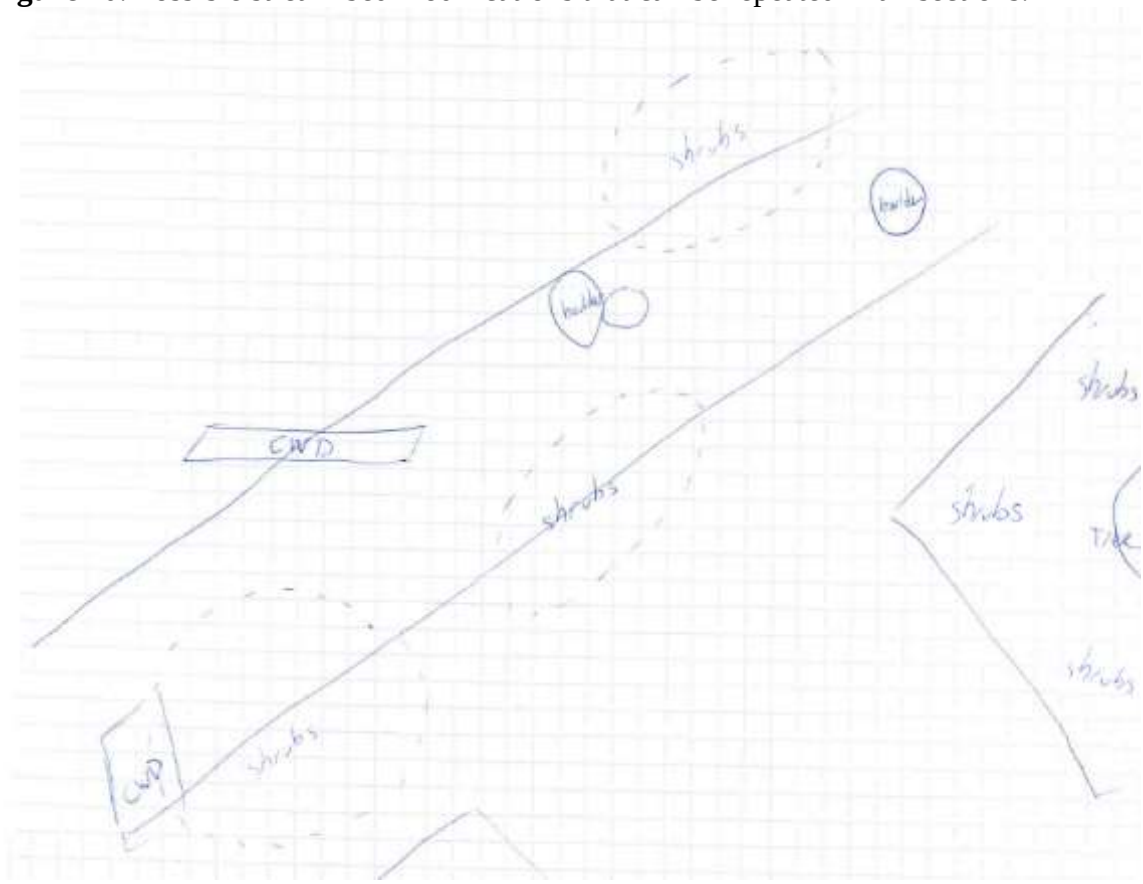
Common Name	Latin Name
Willow	*Salix* spp.
Choke Cherry	*Prunus virginiana*
Alternate Leaved Dogwood	*Cornus alternifolia*
Prickly Gooseberry	*Ribes cynosbati*
Ash	*Fraxinus* spp.
Basswood	*Tilia Americana*
Trembling Aspen	*Populus tremuloides*
Maple	*Acer* spp.

A separate assessment and plan could be done specifically for the stream. Cattails are populating it easily but other species could be added along with some CWD and perhaps some larger cobbles. Table 7 lists some aquatic species that may be suitable. Figure 10 is an example of streambed modifications that could be applied to all sections.

Table 7: Aquatic Species (Evergreen, 2014; Muskoka Watershed Council, 2013)

Common Name	**Latin Name**
Cattail	*Typha latifolia*
Arrowhead	*Sagittaria latifolia*
Broom sedge	*Andropogon virginicus*
Sweetflag	*Acorus americanu*
Arrowhead	*Sagittaria latifolia*
Common rush	*Juncus effuses*
Sweetflag	*Acorus americanus*

Figure 10: Possible stream bed modifications that can be repeated in all sections.



If the current plan appears to work a similar process could be done in the spaces left between 4m plots. These could be younger trees and more emphasis placed on species that did well in the first planting. As the existing plots establish they could be improved by adding understory herbaceous species. Bourgeois et al. (2016b) found that trees planted in post-agricultural riparian zones foster establishment of forest herbs similar to those observed in natural riparian forests. Table 8 lists some suitable species for this process. The challenge would be clearing the grass and keeping the area weed free. Waiting until there is some shade provided and planting shade tolerant species would make this a less labour intensive process.

Table 8: Herbaceous Species (Evergreen, 2014; Muskoka Watershed Council, 2013)

Common Name	**Latin Name**
Bunchberry	*Cornus canadensis*
Wild Strawberry	*Fragaria virginiana*
Trillium	*Trillium erectum*
Tuberous Indian Plantain	*Arnoglossum plantagineum*
Common Wood Sedge	*Carex blanda*
Golden Sedge	*Carex aurea*
Starry False Solomon's Seal	*Maianthemum stellatum*

The wider areas in DS2 and DS3 could have more trees added to turn them into small forest blocks providing more habitat and shelter. This could follow a similar format to the initial plots. The idea of a food forest based on native species and some First Nations traditional management might be interesting to explore in these areas (Figure 11).

Figure 11: Areas that can be turned into forest blocks and perhaps incorporate food forest concepts and First Nations management techniques.

Conclusion

Restoring riparian and woodland habitat along the ditch will benefit both the farmland and the larger ecosystem. The diverse selection of trees and shrubs planted in clusters should create small invasion resistant communities. As the larger plants mature the habitat will become more suitable to herb species native to riparian areas and future plantings can complete the transformation. The selected trees and shrubs provide numerous sources of food including berries, nuts and pollen along with shelter. This will attract other organisms to the area, such as insects, birds and larger mammals, further diversifying and restoring the system. As the plants establish and begin to alter the environment they will create a functioning riparian and woodland area, especially if more work is done along the waters edge and within the stream itself to improve the aquatic habitat. Continued work on this site or merely the passage of time will create a very diverse and resilient habitat, which will also serve to reduce runoff from the fields and improve the connectivity of the larger landscape.

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Appendix 1

Initial Tree Species, Conditions and Reason for Planting

Tree	Reason for planting	Planting conditions
Eastern White Pine	Evergreen, habitat, fast growing, tolerates many soil types	full to partial sun, various moisture and soil types
White Oak	Food source, long lived, deep rooting	variety of moisture and soil conditions, prefers full sun
White Spruce	Shelter and food, evergreen	variety of soil and moisture conditions, shade tolerant
Paper Birch	Food and shelter	full sun, shade intolerant, well drained silty loam soils
American Mountain Ash	Food and shelter, food	full to partial sun, variety of soil, prefers moisture
Pin Cherry	Food	full sun, variety of soil conditions
Shagbark Hickory	Food, found on site	full sun,
Eastern Hemlock	Evergreen, shelter, long lived	any soil type, very shade tolerant, needs moisture
Red Maple	Tolerates variety of conditions, shallow spreading roots	variety of moisture and soil conditions, prefers full sun
Silver Maple	Lots of roots and leaves	moist and rich soil
Yellow Birch	Common to area	full to partial sun, moist rich soil
Bitternut Hickory	Food source	full sun, needs a lot of moisture, rich soil
Northern Hackberry	Elm family, food source	full to partial sun, variety of soil conditions
Black Walnut	Food	full sun, well drained soil, deep rich moist soils
Tamarack	Found on site, variety of conditions	full sun, moist well drained soil, variety of soil and moisture
Eastern Cottonwood	Found on site, short lived so provides habitat when dead and CWD	rich moist soil
Trembling Aspen	Found on site, quick growing	shade intolerant, variety of soil and moisture
Basswood	Food, found on site, nutrient rich leaves	moist rich soils, full sun or full shade